ELECTRONIC FUNDAMENTALS

EXPERIMENT LESSON 32

R-F STAGE, ANTENNA, AND SHIELDING EXPERIMENTS

RCA INSTITUTES, INC.
A SERVICE OF RADIO CORPORATION OF AMERICA
HOME STUDY SCHOOL
350 West 4th Street, New York 14, N. Y.

Experiment Lesson 32

INTRODUCTION

In the experiment lesson dealing with r-f amplifiers you learned that, in TRF receivers r-f amplifiers pick out the stations. Then, in the lesson dealing with converters, you learned that in superhetrodyne receivers it is the local oscillator and not the r-f amplifier that picks out the stations. In the superheterodyne receiver, the r-f amplifier has special functions. The experiments you perform in this lesson will demonstrate one one of its two principal functions in superheterodyne receivers. This function is called *preselection*. The other function is *preamplification*. The prefix *pre* in these two words is intended to mean *before the converter*. The r-f amplifier of a superhetrodyne provides the receiver with selectivity and amplification before the converter. The i-f amplifier provides the superhetrodyne with selectivity and amplification after the converter.

The selectivity provided by a superhetrodyne r-f stage is not as sharp as that which could be provided if an additional i-f amplifier were employed instead. Still, the r-f preselectivity rejects some unwanted signals that cannot be rejected by means of i-f selectivity. One such unwanted signal is an image signal. R-F preselectivity is able to reject image signals solely because the r-f stage is located ahead of the converter.

In this lesson, we will demonstrate:

1. That the superhetrodyne r-f stage provides selectivity.
2. That the superhetrodyne r-f stage rejects image signals.

R-F preamplification, the other principle function of a superhetrodyne r-f stage, improves the receiver sensitivity (enables it to receive weaker stations). This is true even though the receiver would have more gain if an additional i-f amplifier were used instead of the r-f amplifier. The reason is that the weakest station that can be picked up is determined by the strength of the noise generated in the first stage of the receiver. No station that is weaker than this noise can be heard. R-F amplifiers generate less noise than converters. Therefore, receivers with an r-f first stage can receive weaker stations than those with a converter first stage. When the weak station signal reaches the converter after being strengthened by r-f preamplification, it is strong enough to overcome the noise generated in the converter.

We cannot demonstrate the noise defeating properties of r-f preselection experimentally. In order to do so, we would have to be able to control exrernally generated atmospheric noise. This we cannot do. Nevertheless, you must learn that preselection and preamplification go together.

In this lesson, you will also learn that your receiver antenna coil resonates with the r-f tuning capacitor to form a tuned circuit. You will build a loop antenna. You will see that a loop antenna is directional and learn to understand a graph showing antenna directivity. You will use your multimeter as an *S meter* (signal strength meter) to observe the directional characteristics of the loop.

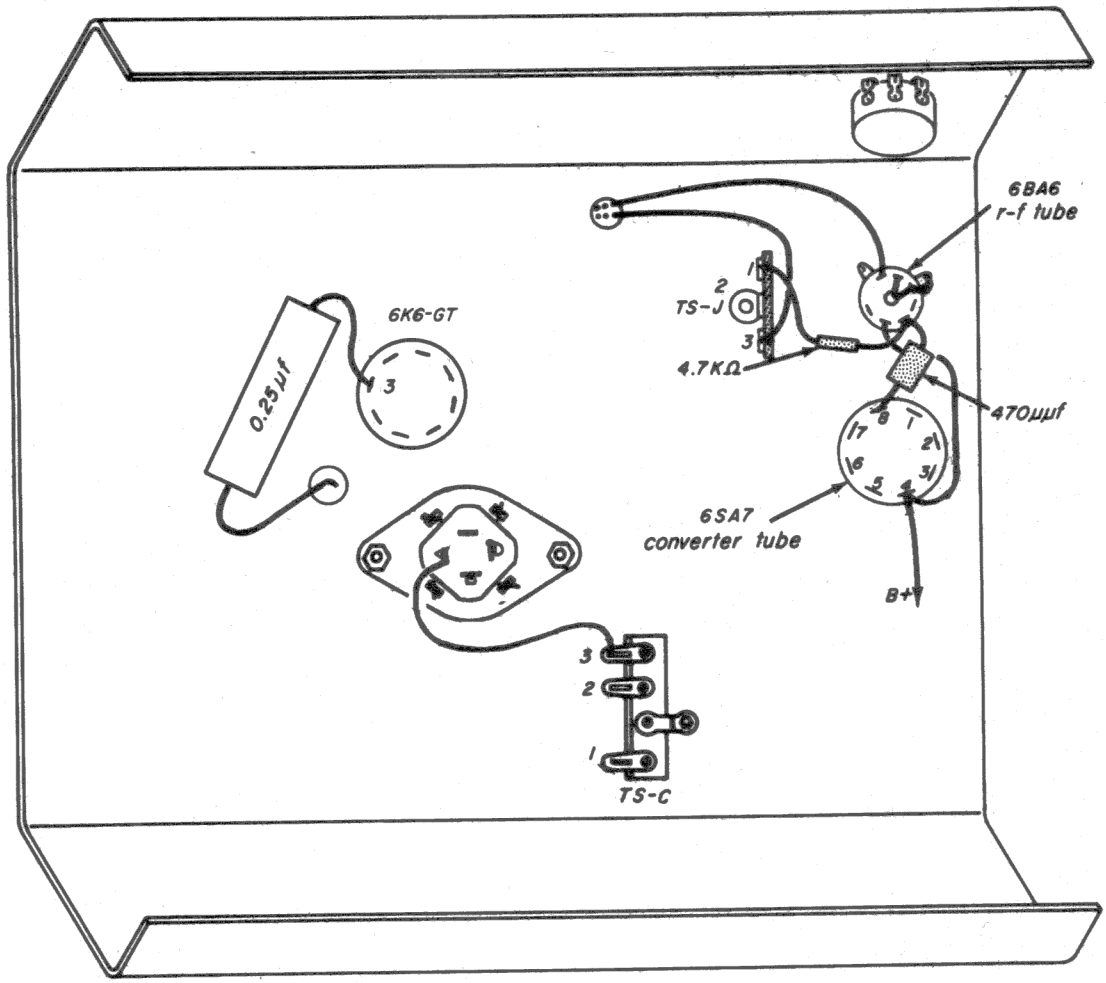


Fig. 32-1

You will see that transformer coupling at r-f frequencies does not always follow the turns ratio rules that you learned early in the course for stepping voltages up or down. Finally you will observe the shieding effect of continuous loops of wire and the effect these have upon the coil being shielded. You will observe that a shield is needed for the 6AT6 tube in your radio and you will install this shield.

EQUIPMENT NEEDED

One 470-μμf fixed mica capacitor

One 270-μμf fixed mica capacitor

One 0.25-μf capacitor

Hookup wire

Magnet wire

Shielded alligator-clip lead

Signal generator

Meter

Cardboard (For quantity, see Jobs 32-6 and 32-7).

Tube shield and base

JOB 32-1

To complete the wiring of the r-f stage of your receiver in preparation for the experiments to follow. Figure 32-1 is a pictorial

diagram of the new wiring underneath the chassis after you have finished Job 32-3.

Procedure.

Step 1. One end of a 4.7 k-ohm ½-watt resistor should already be connected to pin 5 of the 6BA6 r-f tube. (If not, connect it.) Connect the free end of this resistor to TS-J, terminal 1 (Fig. 32-1).

Step 2. Connect a length of hookup wire from pin 6 of the r-f tube to pin 4 of the converter (Fig. 32-1).

Step 3. Connect your 470-μμf fixed mica capacitor from pin 5 of the r-f tube to pin 8 of the 6SA7 converter tube.

JOB 32-2

To install antenna-coil terminals on the top side of the chassis.

Procedure.

Step 1. Completely remove the two leads attached to the terminals of the antenna coil.

Step 2. As shown in Fig. 32-2, mount a two-lug terminal strip on the screw that holds the antenna coil bracket to the rear of the ganged tuning capacitor. We will call this terminal strip TS-L.

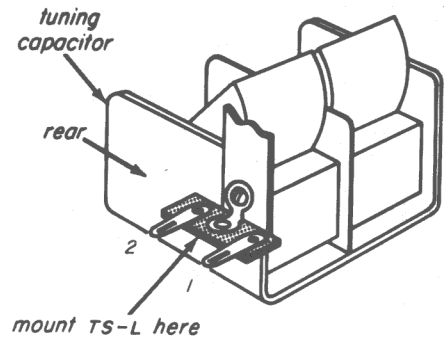


Fig. 32-2

Step 3. Connect the antenna terminal of the antenna coil to terminal 1 of TS-L and connect the other terminal of the antenna coil to terminal 2 of TS-L.

Step 4. Connect terminal 1 of TS-L to the stator lug of the r-f section (front) of the tuning gang.

Step 5. Run a lead from terminal 2 of TS-L through the chassis hole in line with the r-f stator lug of the tuning capacitor and along the bottom surface of the chassis (Fig. 32-1) to terminal 3 of TS-J. Terminal 3 of TS-J is an AVC tie point in your chassis.

Note: The circuit that you are now working with is shown in the schematic Fig. 32-3. TS-L will provide terminals for the antenna coil of your receiver. The antenna coil will be disconnected and a loop antenna coil will be substituted during the course of the experiments in this lesson.

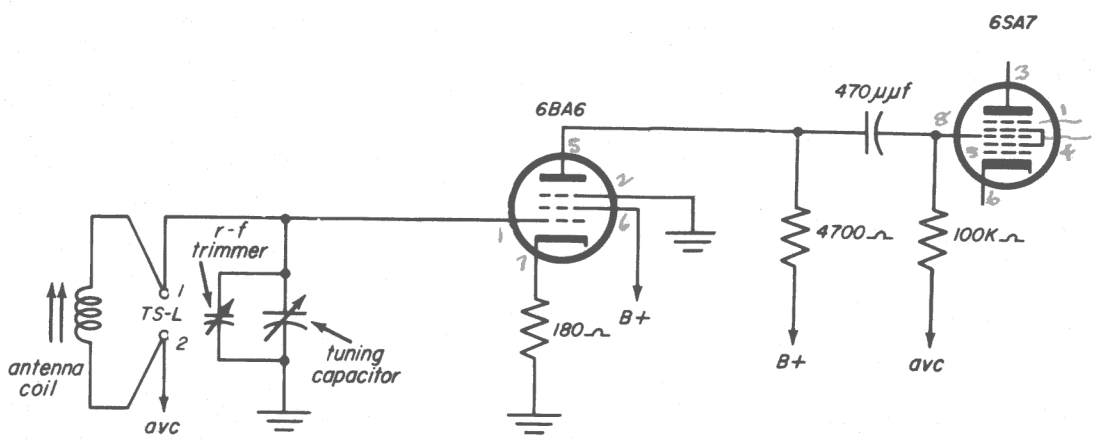


Fig. 32-3

JOB 32-3

To install a temporary test terminal on the top surface of your radio chassis. This terminal is for the purpose of measuring the audio voltage at the plate of the 6K6 audio tube. It will be a convenient place to connect your output meter while you are working on the top surface of the chassis during experiments in this and later lessons.

Procedure.

Step 1. Solder one lead of your 0.25-μf capacitor to pin 3 of the 6K6 socket.

Step 2. Run the other lead of the capacitor through the grommetted hole in the chassis through which the speaker leads pass. Allow the capacitor lead to stick up freely from the top side of the hole. The lead sticking up on top will serve as the test terminal. Push the capacitor flat against the chassis. This arrangement gives you a top side terminal at which the audio signal at the 6K6-GT plate can be measured. The 6K6-GT d-c plate voltage is blocked by the 0.25-μf capacitor.

Step 3. Disconnect, at the ⌓ terminal of the electrolytic capacitor, the lead from lug 3 of TS-C. Connect this lead to the △ section of the electrolytic capacitor. After this change, only the plate of the 6K6-GT tube will receive its B+ from the ⌓ section.

JOB 32-4

To preset adjustments in preparation for the experiments that follow. Figure 32-4 shows the locations of the adjustments.

Procedure.

Step 1. Preset the r-f trimmer adjustment by loosening the screw (turning counterclockwise) until the brass spring-plate no longer follows the head of the screw. Stop before the screw comes out of the threaded hole.

Step 2. Preset the oscillator trimmer. Proceed exactly as in Step 1.

Step 3. Preset the oscillator padder adjustment. Put your screw driver in the padder-screw slot located on the top surface of the chassis. Tighten the screw by turning counterclockwise. Tighten only until you feel a slight opposition to your turning. Do not force the screw.

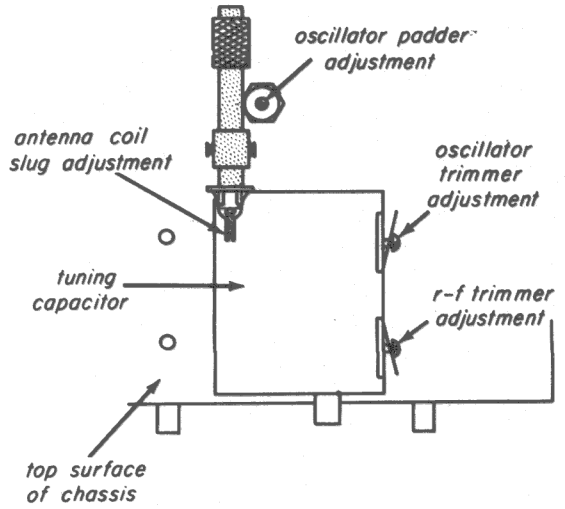


Fig. 32-4

Step 4. Preset the antenna coil slug. Position the slug in the coil so that the rear of the slug is flush with the rear of the coil form.

Note: Following these instructions does not set up your radio to properly tune in broadcast stations. The procedure provides a standardized starting point for the experiments that follow.

JOB 32-5

To wind a permanent coupling coil on the antenna coil form. This coupling coil will provide a means of connecting your signal generator to the r-f section of your receiver without detuning the r-f section. It will be used for this purpose in this and later lessons. Also, it will provide a means of connecting a long wire outdoor antenna if you ever want to do so.

Procedure.

Step 1. Unsolder and remove the pickup coil. Cut off a 5-inch length of hook-up wire. Remove the insulation from both ends of the wire.

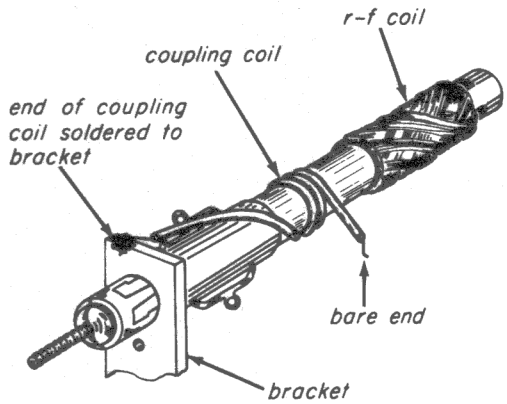


Fig. 32-5

Step 2. Solder one end of this wire to the top of the antenna-coil mounting bracket as shown in Fig. 32-5.

Step 3. As shown in Fig. 32-5, wind the wire around the antenna coil form to make a 3-turn coil. The free end of the wire, which is bare, will serve as an r-f input terminal to which your signal generator output cable or a long wire antenna can be attached.

EXPERIMENT 32-1

To draw a graph of your receiver's r-f response and to show that the superhetrodyne r-f stage provides selectivity to the receiver.

Information. A schematic of the circuit that you will work with is shown in Fig. 32-6. The tuning and trimmer capacitors of the r-f stage will be disconnected and a 270-μμf fixed capacitor substituted in their place across the antenna coil. With the r-f section of the tuning gang disabled, only the oscillator section can operate. Turning the shaft of the tuning gang will change the oscillator frequency and thus change the r-f frequency to which the receiver responds. However, the r-f frequency to which the r-f stage responds will remain fixed

You will draw a graph showing the output of the receiver at the various r-f frequencies with the same strength of input applied at each frequency. The graph should show a much larger receiver output at the frequency to which the r-f stage is fixed-tuned.

Procedure.

Step 1. Disconnect the two leads from the stator lug of the r-f section (front section) of the tuning gang. Keep the two leads soldered together but bend them away from the stator lug.

Note: You will not need to work on the underside of the chassis. Keep the chassis top-side-up in its normal playing position.

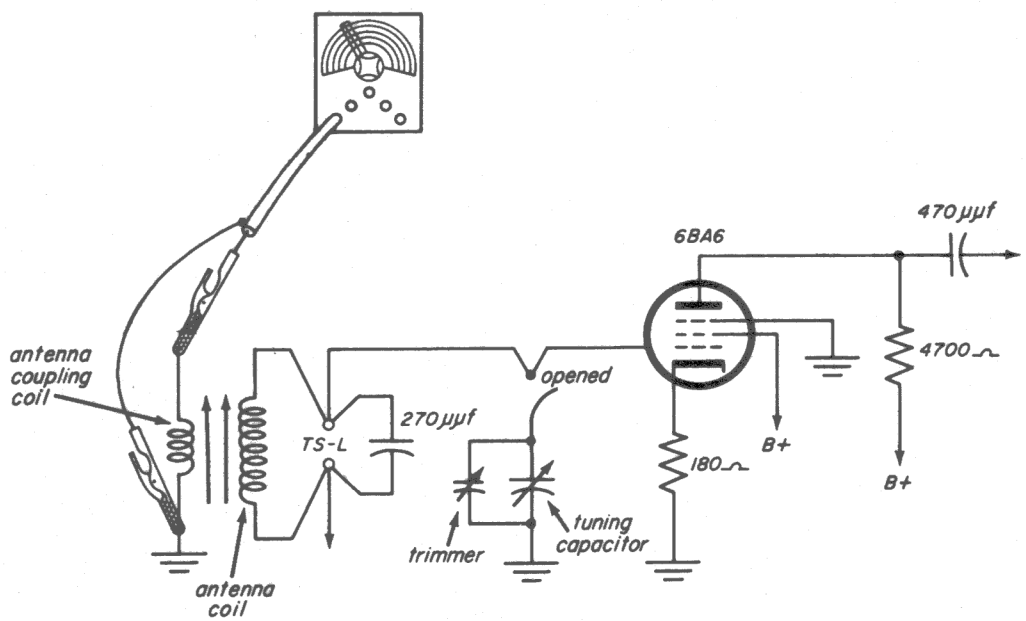


Fig. 32-6

Step 2. Install a 270-μμf fixed mica capacitor between terminals 1 and 2 of TS-L.

Step 3. Turn on your signal generator--r-f output ¼ turn from off -- modulation on--selector to band B. Connect the ground lead of the r-f output cable to your radio chassis and the hot lead to the terminal of the antenna coupling coil that you wound in Job 32-5.

Step 4. Set your multimeter connected as an output meter to 75 VAC scale. Connect one meter lead to your radio chassis, and the other to the temporary audio test terminal that you installed in Job 32-3 on top of of your radio chassis.

Step 5. Turn on your radio. Set the ganged tuning capacitor maximum counter-clockwise.

Step 6. Set the signal generator to 525 kc. Turn up the radio volume, and slowly turn the tuning capacitor clockwise. Stop when the meter pointer reaches a maximum.

Step 7. Your receiver is now set to 525 kc. Adjust the volume control of the receiver so that the meter reads 15 volts a.c.

Step 8. From here on, do not alter the setting of the radio volume control or the signal generator r-f output control. Set the signal generator to 550 kc then to 575 kc, 600 kc, and all the settings on the horizontal axis of the graph in Fig. 32-7. Each time you reset the generator, reset the tuning gang for maximum meter reading. Record the reading each time on the blank graph paper that is provided at the end of the lesson.

Note: If you have trouble with squeals, whistles, or motorboat sounds, drop your tube shield over the 6AT6 tube.

If you pick up broadcast stations on the radio at the test frequencies, rotate the chassis (keeping it flat on your work bench) until the sound from the station is at a minimum.

Each time you adjust the tuning gang for a maximum on the meter, be sure you hear the 400-cps modulation tone of the signal generator so you will be sure that the signal that you are tuning to maximum is actually the one delivered by the generator and not one picked up accidentally.

Step 9. The graph that we plotted in our laboratory is shown in Fig. 32-7. As you

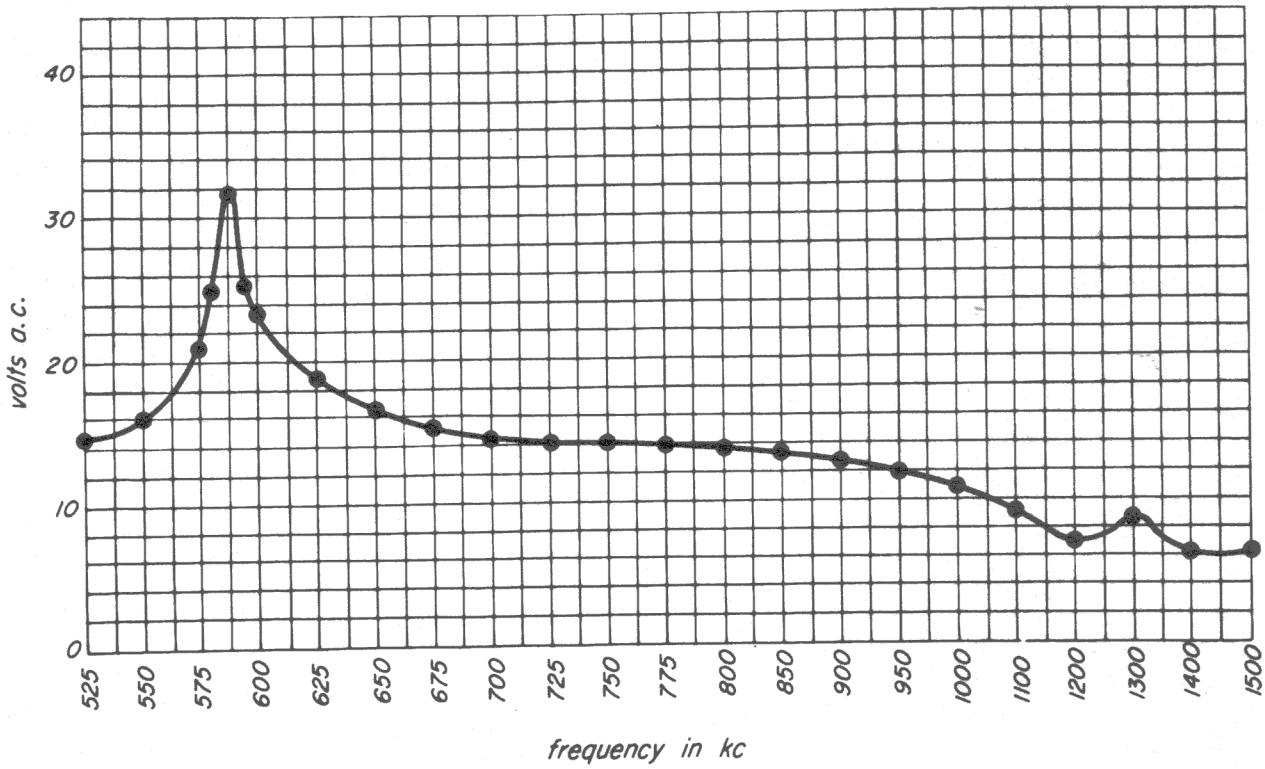


Fig. 32-7

see, it will be necessary to take a few readings at close frequency intervals as you approach the peak of the response curve of your receiver.

Information. The graph shows that your superheterodyne receiver's r-f response rises sharply at the frequency to which the r-f stage responds. Because the response of the receiver is much less at frequencies to each side of the one to which the r-f stage responds, we say the r-f stage is selective.

In normal operation, the r-f stage is always tuned to respond to the r-f frequency to which the remainder of the receiver responds as determined by the frequency setting of the local oscillator. For this to be so, the r-f section of the tuning gang must track with the oscillator section. When you tune from one station broadcasting at one r-f frequency to another station at another r-f frequency, the oscillator frequency must change to a frequency that will produce a 455 kc i.f. when it beats with the new r-f frequency. At the same time, the maximum response of the r-f stage must change to the new r-f frequency.

The two sections of the tuning gang will not track unless they are adjusted to track by means of the trimmer, padder, and antenna-coil slug. You will make these adjustments when you study the lesson dealing with alignment of your receiver. At present, the two sections of the tuning gang do not track precisely.

EXPERIMENT 32-2.

To show that the r-f tuned circuit rejects image signals.

Information. In this experiment, you will use the same fixed tuned r-f tank circuit as in Experiment 32-1. You will tune in a station higher in frequency than the frequency to which the r-f stage now responds as shown on the graph you plotted. Then you will feed the image signal from the signal generator to your receiver. (In your receiver, the frequency of an image is always 910 kc higher than the station tuned in.)

The image signal from the generator will interfere with the station tuned in. The interference shows up as a whistle. You will retune the r-f tank to respond to the frequency of the station tuned in. When you do so, the preselectivity of the r-f stage will reject the image signal and the whistle will not be heard.

Procedure.

Step 1. Connect your external antenna to the terminal of the antenna coupling coil.

Step 2. Couple the output of your signal generator to your external wire antenna. To do this, twist a piece of hookup wire around the antenna wire and connect the hot lead of the generator to the hookup wire. Connect the ground lead of the generator to your radio chassis.

Step 3. Tune in a station above the frequency to which the r-f tank now responds as shown on your graph.

Note: If possible, choose a station below 800 kc so that the image will be on band B of your signal generator. The image of stations higher than 800 kc will be on band C.

Step 4. Calculate the frequency of the image by adding 910 kc to the frequency of the station tuned in. You can find out the frequency of the station tuned in by listening until the announcer tells the name of the station. Then look up the station in the program listings of a newspaper to find out the frequency. Or, you can measure the stations frequency by the beat method, using your signal generator.

Step 5. Set the signal-generator frequency control approximately to the image frequency. Adjust the control to the setting that produces a whistle.

Step 6. Retune the r-f tank to the frequency of the station tuned in by turning the antenna coil slug counterclockwise until the station sound is loudest. Note that the whistle cannot be heard when the station is loudest. The station is loudest where the slug tunes the tank for the best response to the station.

Discussion. This experiment shows that r-f preselectivity rejects image signals. Image signals do not always cause interference whistles. The interference occurs only if there is a station at both the fundamental frequency (the frequency tuned in) and at the image frequency. Otherwise, the only effect of image reception is to cause the same station to come in at two points on the radio dial.

JOB 32-6

To construct a loop antenna.

Information. A receiver antenna may be *any conductor of electricity* that is positioned to intercept the signal from a broadcast station and that is connected to the input of the receiver. When you remember this, it is clear that the coil in the r-f tank circuit will function as an antenna unless it is shielded against the station signal. Ordinarily, however, the r-f tank coil is not a good antenna because it does not intercept enough signal. When the r-f coil is to function as an antenna, steps are taken to cause it to intercept more signal. There is more than one way to accomplish this.

The antenna coil in your receiver is an r-f coil used as an antenna. The pickup ability of the coil is increased by means of winding it on a ferrite core. The ferrite contributes a large portion of the total inductance of the coil. Therefore any signal picked up on the core is well coupled to the tank. The ferrite is a good interceptor of signals.

Another way to improve the pickup ability of an r-f coil is to spread its turns out over a wide area. An antenna coil made in this way is called a loop antenna. A loop has a unique directional response that you will study in this lesson. Right now you are concerned only with building the loop. The important things to know about building it are that the wire must be spread out in wide loops and that the loops must form a coil, the inductance of which is just right to resonate with the r-f tuning capacitor at the broadcast station frequencies. In other words, the inductance of the loop you build should, if possible, equal the inductance of your antenna coil when it is adjusted for proper tracking. The loop you are about to build meets these requirements as nearly as possible.

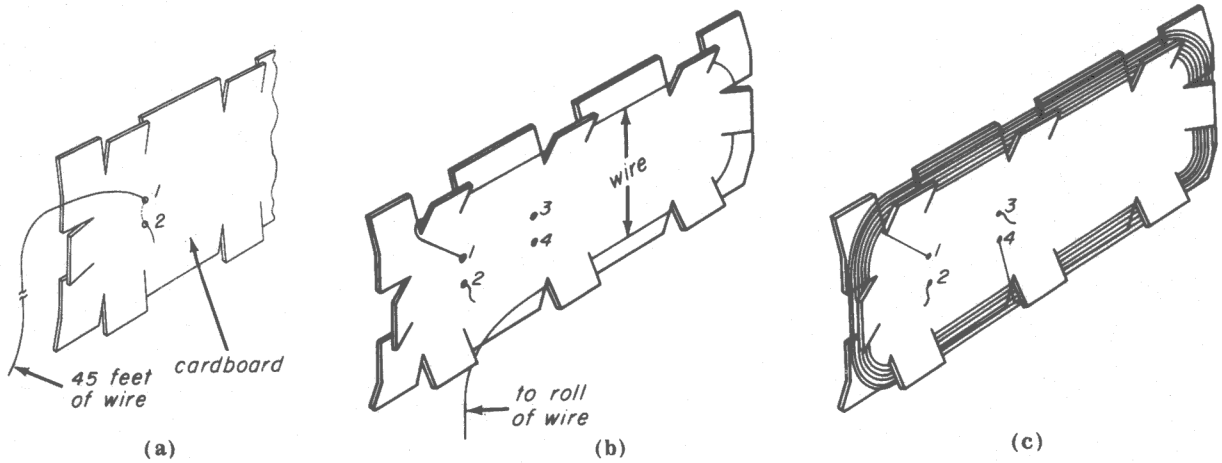
Procedure.

Step 1. Turn to the end of this booklet and cut out the template provided. (A template is a guide or pattern. You will use this template as a pattern for the support for your your loop antenna.) Paste this template on a piece of cardboard. Cut the cardboard down so that it has the shape and size of the template. Make slits in the cardboard along the dotted lines on the template.

Step 2. Punch out the four small holes marked 1,2, 3 and 4 on the template.

Step 3. Measure off 45 feet of magnet wire. You should have enough wire on your spool. If not, you can unwind 45 feet from the electromagnet winding that you made early in the course.

Step 4. Loop the end of the 45-foot length of wire through holes 1 and 2 in your cardboard as shown in Fig. 32-8*a*. Allow the short end of the wire to extend through hole



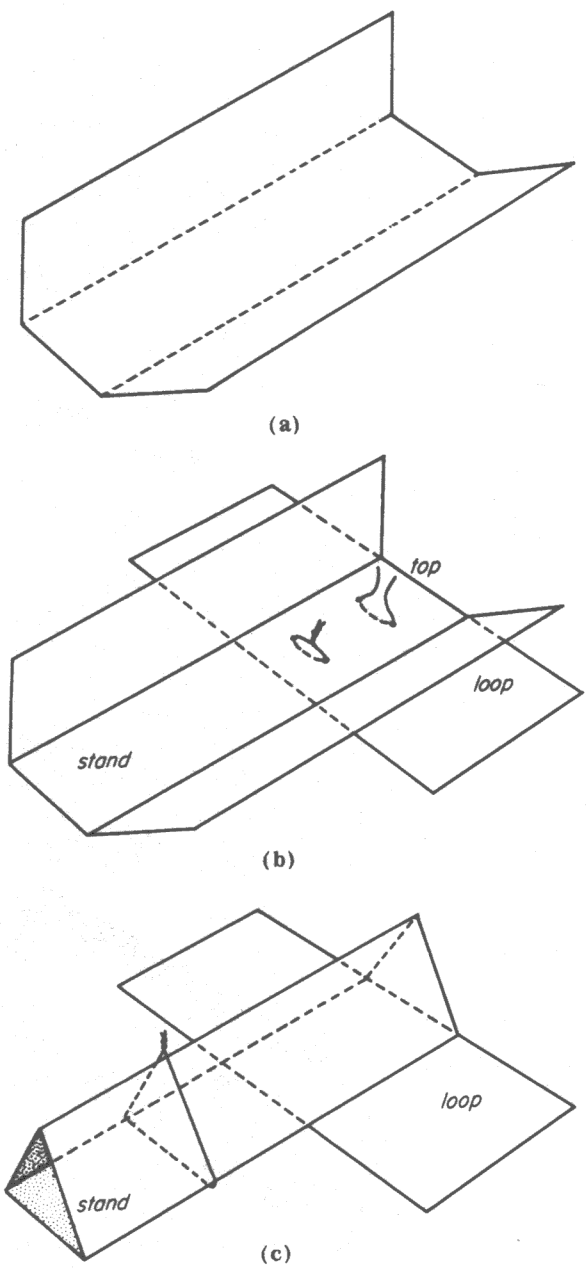
(a) (b) (c)

Fig. 32-8

2. The wire extending through hole 2 will be one terminal of your loop antenna.

Step 5. Wind the loop as shown in Fig. 32-8*b*. Use up the full 45 feet of wire. When the loop is wound, it should look like Fig. 32-8*c*. Loop the finished end of the wire through holes 4 and 3. The wire extending through hole 3 is the second terminal of your loop antenna.

Step 6. To make a cardboard stand for your loop, cut out the template provided at the end of this lesson. This template is labeled as the template for the loop-antenna stand. Mount this template on a piece of cardboard. Cut the cardboard down so that it is the same shape and size as the template. Bend the cardboard along the dotted lines on the template as shown in Fig. 32-9*a*.



(a)

(b)

(c)

Fig. 32-9

Step 7. Attach the loop antenna to the top of the center fold of the cardboard stand as shown in Fig. 32-9*b*. Lace the cardboard of the stand to the cardboard of the loop with magnet wire. Use the magnet wire to hold the two together as if it were thread used to hold two pieces of cloth together.

Step 8. Bend the cardboard of the stand to form a triangle as shown in Fig. 32-9*c* and bind it with a piece of magnet wire as shown.

EXPERIMENT 32-3.

To plot the directivity pattern of the loop antenna.

Information. A loop antenna responds better to signals arriving from some directions than from other directions. You are going to tune in a station and measure the strength of signal that your receiver picks up. Then you are going to rotate your loop antenna by degrees causing the loop to pick up the station's signal from various directions. On the graph paper provided at the end of this lesson, you will mark down the strength of signal picked up each time you rotate the position of the loop. When you join the marks by a line, you will have a polar graph of your loop antenna's response to signals from various directions.

The ideal polar response of loop antennas is shown in Fig. 32-10*a*. The two circles in the figure-eight pattern are called lobes. Now suppose the signal picked up by a loop is combined with the signal picked up by another stationary antenna and then the loop is rotated and a response curve is drawn. The response will not be like the ideal response shown in Fig. 32-10*a* because signal from the two antennas will add in some positions of the loop and oppose in others. The response may have unequal lobes (Fig. 32-10*b*); or it may have one lobe (Fig. 32-10*c*). For certain reasons, a loop response may also have no lobes (32-10*d*).

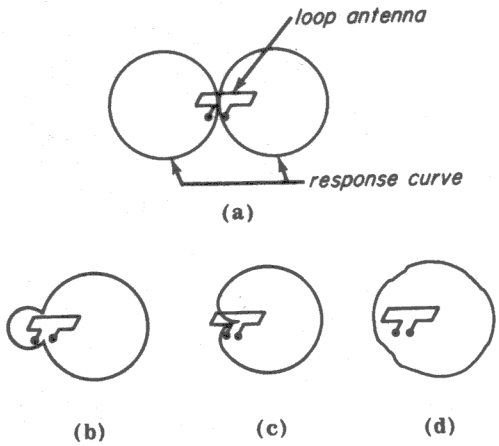


Fig. 32-10

The loop with which you are experimenting is called a high-impedance unbalanced loop. It is the kind most used in home radio receivers. It is called *high impedance* because it is the coil *(L)* of a parallel resonant *LC* circuit—the r-f tank circuit. You probably recall that a parallel resonant circuit is a high impedance device. The loop is called *unbalanced* because one of its terminals is grounded. The loop would be balanced if both terminals were ungrounded and the impedances between each terminal and ground were equal. A balanced loop would have its ground connection located in the center of the loop winding. Loops used with radio-direction finding equipment for navigating ships, etc. are always balanced.

There are other kinds of loops. Some home radios are equipped with a loop that is not the coil part of a parallel resonant circuit and is at a low impedance.

An unbalanced loop, such as the one you are working with, can never have a perfect figure-eight response curve. Signals picked up near the ground end of the winding get grounded out by stray shunt capacitance. As a result, one side of the loop delivers more signals to the radio receiver than the other side. The extra signal from the hot side has the same effect on the response characteristic as does a signal picked up on a second (stationary) antenna and combined with the signal picked up on the loop. Therefore, the response curve that you plot is more likely to look like Fig. 32-10*b* than the ideal figure-eight response (Fig. 32-10*a*).

The response curve plotted in our laboratory is shown in Fig. 32-11. However, the curve you plot may be different than ours.

It is not likely to get a curve like Fig. 32-10*c*. To get this curve, requires a second (stationary) antenna with just the right amount of coupling to the loop in exactly the right phase. If a signal is picked up on the loop in equal strength, no matter in what direction the loop is rotated, there will be no lobes on the response curve. Instead, the response curve looks like Fig. 32-10*d*.

You might get a curve something like Fig. 32-10*d* if you tune in a station above 1,500 kc to plot your loop response. The loop may have such a response above 1,500 kc because, at high frequencies, reradiation and and a phenomenon called *night effect* causes the loop to pick up equal signal regardless of its rotation position. Night effect is the strong reception of the sky-wave signal from the station tuned in. The sky wave is stronger at night. Also, you might get a curve like Fig. 32-10*d* if your loop is close to metal objects that can pick up a signal from the

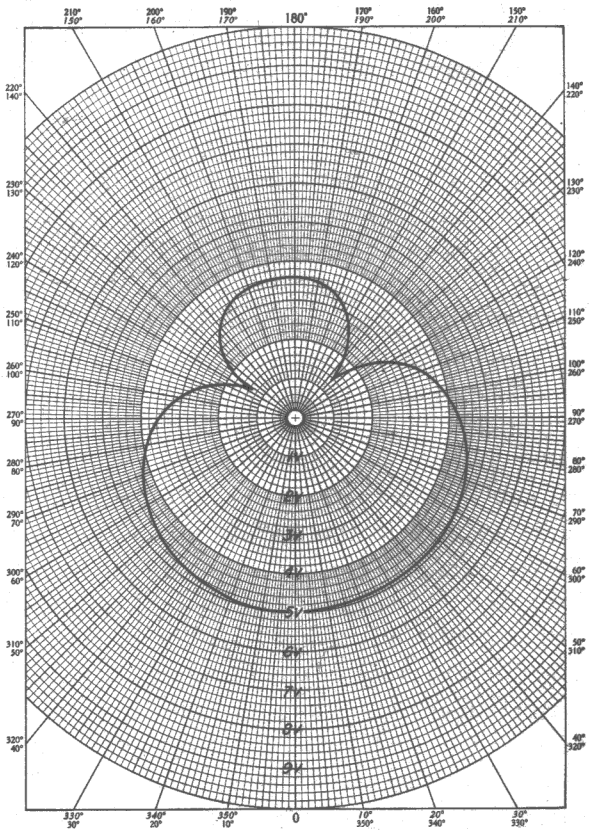


Fig. 32-11

station you are receiving. The metal objects might reradiate the signal to the loop from a direction different than the direction of the station.

Normally, a loop is rotated in an imaginary circle that is flat against the ground. Rotating the loop changes the angle at which the ground wave meets the loop windings. The loop response is directional to the ground wave. However, the sky-wave signal comes down to the loop from above and therefore the loop picks up the same amount of sky-wave signal regardless of the horizontal position of rotation of the loop.

Procedure.

Step 1. Resolder the two leads to the stator lug of the r-f section of your radio's tuning gang that were removed in Experiment 32-1.

Step 2. Unsolder from TS-L the 270-$\mu\mu$f fixed mica capacitor and the two leads of the antenna coil.

Step 3. Connect terminals 2 and 3 of your loop to the two terminals of TS-L by means of two 24-inch lengths of wire.

Step. 4. Pencil mark the center of the base of the cardboard stand upon which your loop is mounted as shown in Fig. 32-12.

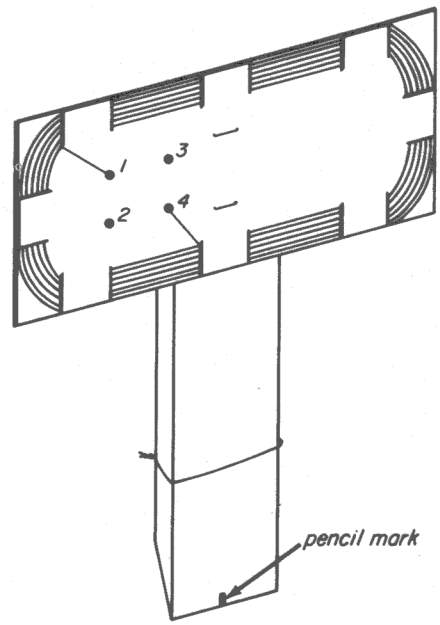


Fig. 32-12

Information. You must connect your meter to your radio to get an indication of the strength of signal picked up on the loop. For this purpose, it is not satisfactory to connect your meter to measure the audio voltage at the plate of the 6K6 tube. The audio voltage is the modulation component of the r-f signal coming in to your receiver. When the incoming r-f signal is from your signal generator, it is satisfactory to measure the audio modulation component as an indication of the strength of the r-f signal; the 400 cps modulation from your generator is a constant a-c voltage. However, the audio modulation component of an r-f signal from a broadcast station represents speech or music and is not a constant voltage; it cannot indicate the strength of the r-f signal because it is a varying a-c voltage while the carrier remains constant.

To get an indication of the strength of signal picked up by your loop, you will connect your meter to the diode detector output in your radio and measure the d-c voltage. This voltage is proportional to the strength of signal picked up on the radio antenna. (As you know, the second detector d-c voltage is used as an AVC control voltage. This is possible only because the voltage is proportional to the strength of the r-f signal.)

When a meter is connected to a radio to show the strength of signal being received, it is called an *S* meter *(S* for signal strength). The meter connection you will use makes for a basic kind of *S* meter. More complex *S* meters are described in another part of the course.

Step 5. To connect the meter, use your shielded lead with the alligator clips attached. Run the lead through the unused hole on the rear apron of the chassis. Clip the shield wire to chassis ground and clip the center wire to terminal 2 of TS-C at the

junction of the lead from terminal 3 of the volume control and a 3.3-megohm resistor.

Plug the other end of the shielded wire into the POS jack on your meter. Plug the center wire into the COMMON jack on your meter. Set the meter on the 25 VDC range.

Step 6. Tune in a station, preferably in the mid-range of the tuning capacitor.

Step 7. Grasp the loop stand and, holding the stand flat against your work surface, rotate the loop. Rotate it in an imaginary circle that is flat to your work surface. Stop rotating immediately when your meter indicates maximum deflection.

Step 8. If the maximum deflection of your meter needle is over 5 volts, take the readings to follow on the 25 VDC range. If not, switch to the 5 VDC range to take the reading.

Step 9. Your loop is now pointed approximately at the station tuned in. Tear out the polar graph paper at the end of this lesson and slip it under the base of your loop stand as shown in Fig. 32-13*a*. The pencil marked center of the base of the stand must line up with the center mark on the graph paper and the front (pencil marked) edge of the base must be in line with the 0° - 180° line on the paper.

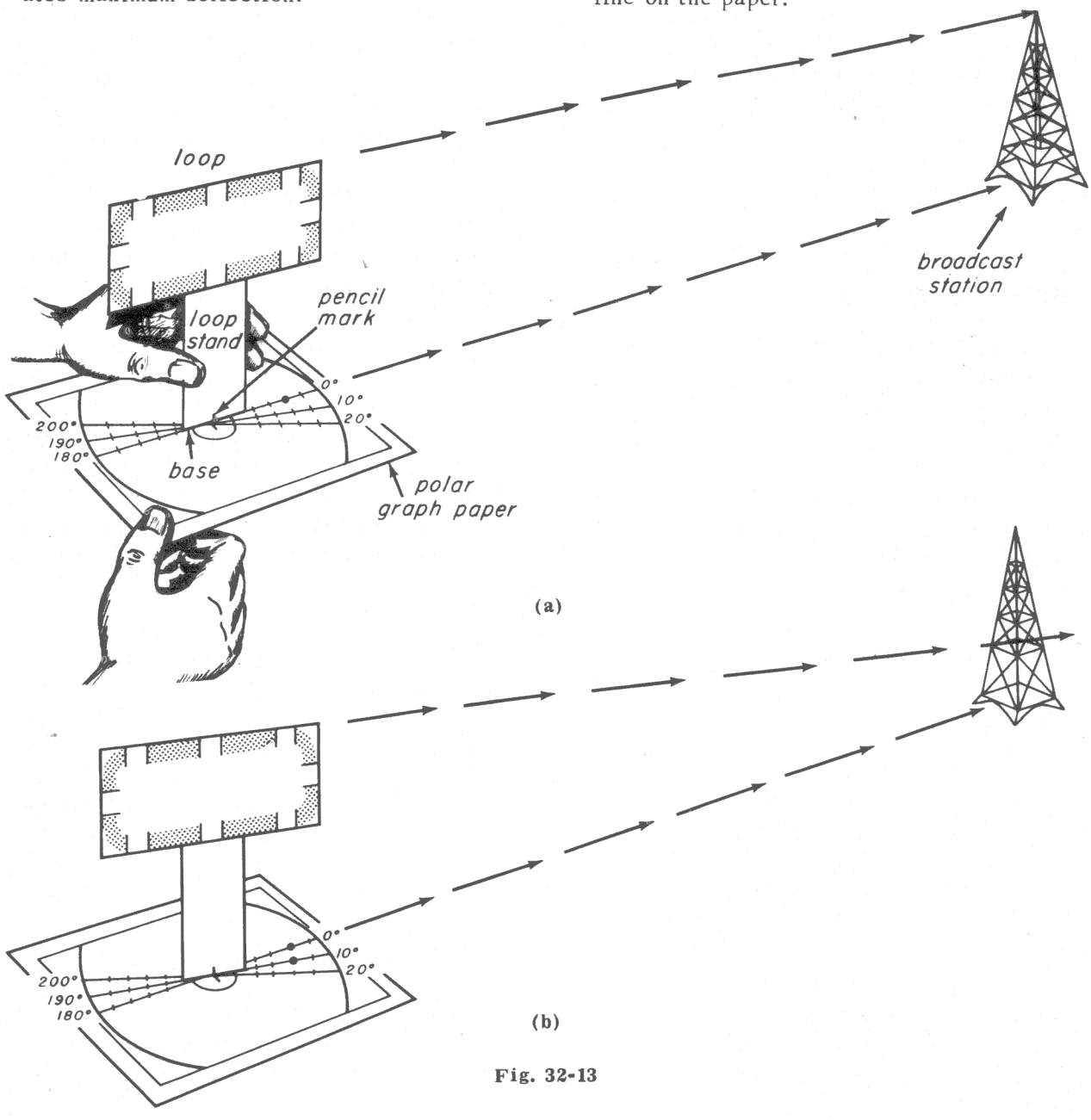


Fig. 32-13

Step 10. Now 0° on your polar graph paper is pointing toward the station tuned in. Note the reading registered on your meter and mark it on the 0° line on your paper, as shown in Fig. 32-13*a*.

Step 11. Rotate the loop so that the front edge of the base of the stand lines up with the 10° - 190° line (Fig. 32-13*b*). Keep the pencil marked center of the base on the center mark. Now mark the meter reading registered in this position on the 10° line.

Step 12. Continue to rotate the loop in 10° intervals, marking the meter reading on the appropriate line in each rotation position. Be careful not to shift the position of your graph paper. Continue until your loop returns to the position described in Step 10.

Step 13. Join the points you have marked with a curving line.

EXPERIMENT 32-4

To show that transformer coupling at r-f frequencies may not follow the rules for stepping up voltages according to turns ratio.

Information. The formula which you learned for stepping up voltage in an ideal transformer is as follows:

$$\frac{E_2}{E_1} = \frac{N_2}{N_1}$$

Where:

E_1 = primary voltage
E_2 = secondary voltage
N_1 = number of turns in the primary winding
N_2 = number of turns in the secondary winding as shown in Fig. 32-14.

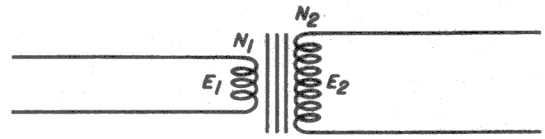


Fig. 32-14

According to this formula, if you *increase* the number of turns on the primary (N_1) you *decrease* the secondary voltage (E_2). For example, if $E_1 = 2$ volts, $N_1 = 2$ turns, and $N_2 = 4$ turns, E_2 should equal 4 volts. If you *increase* N_1 to 4 turns, E_2 should decrease to 2 volts. However, this formula only holds true for an ideal transformer in which all the electric energy in the primary is converted to magnetic energy in the core and all the magnetic energy is transferred to the secondary. The power P_1 in the primary must equal the power P_2 in the secondary. At r-f frequencies, it is difficult to get all the primary energy transferred to the secondary. The power P_2 in the secondary is less than the power P_1 in the primary. Increasing the primary turns N_1 then *increases* P_2 and therefore *increases* E_2. Increasing the amount of power transferred from primary to secondary in an r-f transformer is called *increasing the coupling* between primary and secondary. Coupling can be increased by increasing the primary turns or by moving the primary closer to the secondary. In this experiment, you will increase the number of turns on the antenna coupling coil, a primary winding, which you wound on your antenna coil, and you will see that the secondary voltage increases. You will be increasing the coupling between the two coils.

Procedure.

Step 1. Unsolder the loop antenna leads from TS-L.

Step 2. Solder the leads from your antenna coil to the terminals of TS-L.

Step 3. Unplug the 6SA7 tube.

Step 4. Set up your meter as an output meter.

Step 5. Insert the probes of your meter into pins 1 and 8 of the 6SA7 socket on the

top side of the chassis. The meter is now connected to indicate the r-f output voltage of the r-f amplifier which corresponds to the r-f voltage across the terminals of the antenna coil connected to the control grid of the r-f tube. Be sure not to intertwine the meter leads. Do not touch the meter leads.

Step 6. Turn on your radio and turn on your signal generator. Set the generator at 1,000 kc, the band B, r-f output maximum, modulation off.

Step 7. Connect the shield wire of your signal generator r-f output cable to your radio chassis. Connect the hot (center) wire to the terminal of your antenna-coupling coil.

Step 8. Slowly rotate the radio tuning gang until your meter pointer deflects to maximum, at which setting the r-f tank is tuned to 1,000 kc corresponding to the setting of your signal generator.

Step 9. Note the position of your meter pointer. It corresponds to a certain value of r-f voltage at the secondary (antenna coil) winding of the r-f transformer you are testing. You will see that the pointer deflects more when you increase the primary (coupling coil) turns.

Step 10. To increase the number of turns on the coupling coil, solder a 4-inch length of insulated wire to the present coupling-coil terminal end and wind this added wire around the antenna coil form in the same way that the coupling coil is wound.

Step 11. Clip the hot lead of your signal generator to the end of the added wire and note that the meter now deflects more than before; this indicates that the secondary (antenna coil) terminal voltage (E_2) is greater than before. You have decreased the turns ratio, increased the coupling between the two coils, and the r-f voltage coupled to the secondary coil has increased.

Information. The next experiments have to do with shielding r-f coils and other components. Shielding prevents accidental coupling to r-f coils, and etc. Without shielding, stray r-f signals might be coupled to an r-f coil. The stray signals can interfere with the wanted signal. Also, accidental coupling can form a regenerative feedback path and cause an amplifier circuit or a series of amplifier circuits to oscillate. (You remember that an amplifier with feedback becomes an oscillator.)

The accidental coupling can be of two kinds, capacitive and magnetic. Fig. 32-15*a* illustrates accidental capacitive coupling. The capacity (C_1) that exists between one circuit and another is in series with the stray capacity to ground of the second circuit and forms a capacitive voltage divider. R-F voltage existing to ground in the first circuit divides between C_1 and C_2. Of course, the portion across C_1 is in fact coupled to the second circuit.

As shown in Fig. 32-15*b*, placing a grounded sheet of metal between the two circuits returns the C_1 capacity directly to ground and prevents it being in series with C_2. Therefore, the grounded sheet of metal prevents capacitive coupling between the two circuits. It is called a *capacitive shield* or *Faraday shield.*

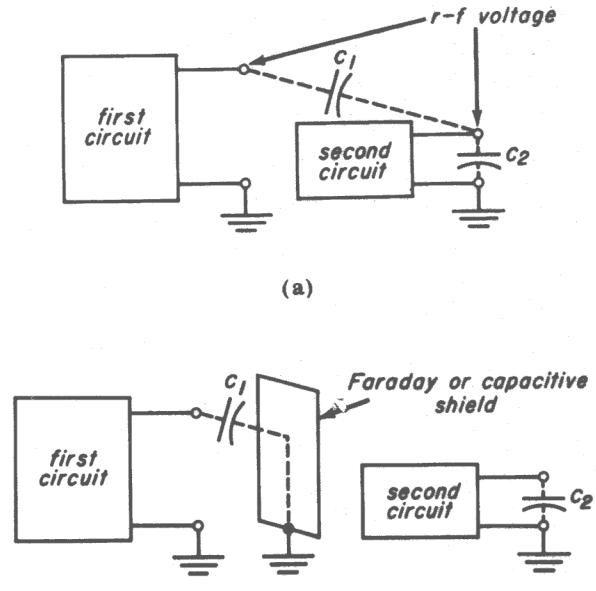


Fig. 32-15

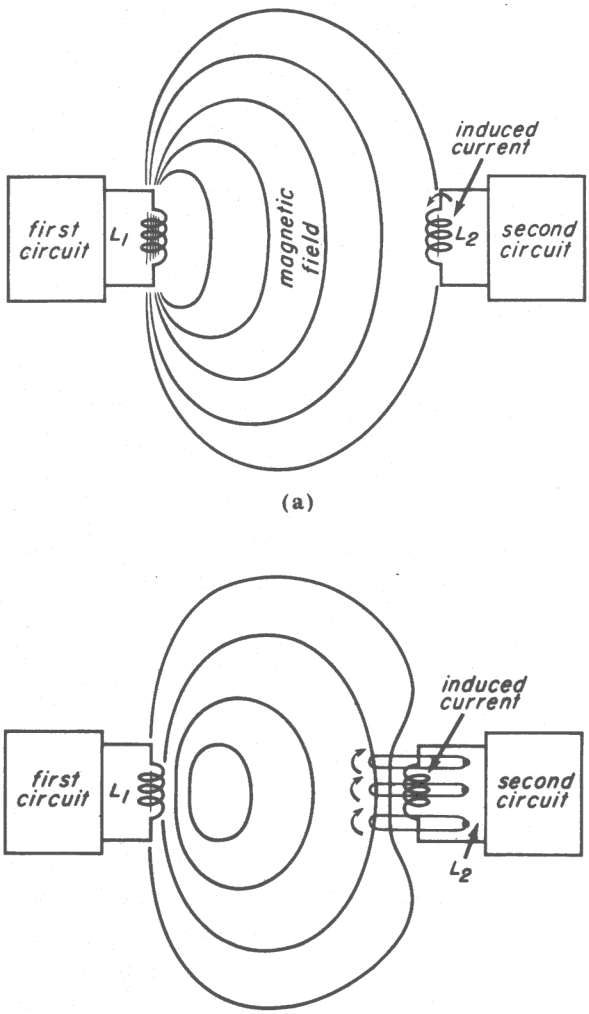


Fig. 32-16

Figure 32-16*a* shows how two circuits can be accidentally coupled magnetically. The coil L_1 induces a current in the coil L_2. To prevent magnetic coupling, a series of continuous loops of wire can be placed around L_2 (Fig. 32-16*b*). Then L_1 induces the current in these loops instead of L_2. The loops can be thought of as short-circuited step-down transformer secondary windings that draw so much power from the magnetic field surrounding them that they destroy the field. They draw power from and destroy only the portion of the total magnetic field that is close to them. If either L_1 or L_2 is very close to the shorted turns, the shorted turns may draw power from it. Drawing much power from a coil, whether by magnetic coupling or direct coupling, is the same as placing a low impedance across the terminals of the coil or shorting it out. For this reason, the conducting-loop shield must not be too close to a coil being magnetically shielded.

A grounded metal cylinder is both a magnetic and capacitive shield. The metal cylinder is a series of shorted turns of wire piled one on top of the other to form a magnetic shield. When it is grounded, it serves as the intervening sheet of grounded metal needed to make up a capacitive shield.

Radiated signals like those from radio stations are made up of both a magnetic and capacitive component. To eliminate accidental coupling of a radiated signal, a shield must be used that prevents both capacitive and magnetic coupling.

In the following experiments, we will show that a single shorted turn wound close around the antenna coil of your receiver loads (draws power from) the coil to such an extent that almost none of the signal received from a broadcast station gets applied to the r-f amplifier grid. You will know this because the volume will decrease greatly when you place the shorted turn over the antenna coil.

Next, we will show that a single shorted turn that is not close around the antenna coil does not load it. Then we will show that, although shorted turns wound around the antenna coil but not close to the coil do not load the coil, a series of these shorted turns has a shielding effect and reduces the amount of signal picked up.

Finally, we will show that a shield is needed around the 6AT6 tube in your radio, and you will install the shield.

EXPERIMENT 32-5

To show that a close wound shorted turn loads your antenna coil and cuts off the signal.

Step 1. Unwind the extra length of wire from your antenna coupling coil. Unsolder and remove the wire.

Step 2. Remove the meter probes from the 6SA7 socket. Install the 6SA7 tube.

Step 3. Be sure that the slug in the r-f coil is flush with the rear of the coil form.

Step 4. Wind a single turn of hookup wire around your antenna coil. Twist the ends of the wire together and solder the twist. Slip the turn of wire off the antenna coil.

Step 5. Tune in a station on your radio.

Step 6. Slip the shorted turn over the antenna coil and note that the sound gets much weaker.

JOB 32-7

To mount a series of shorted turns for use in the next experiments.

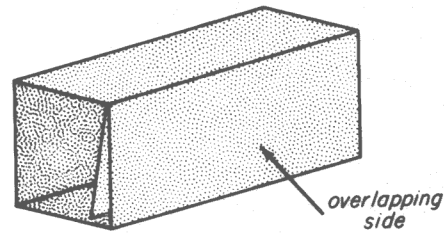
Procedure.

Step 1. Cut out the template for a box at the end of this lesson. Paste the template on a piece of cardboard. Cut the piece of cardboard down to the size and shape of the template. Bend the cardboard along the dotted lines on the template so that it folds in the shape of a box. Since there are five segments on the template, the box will have one side that overlaps, as shown in Fig. 32-17*a*.

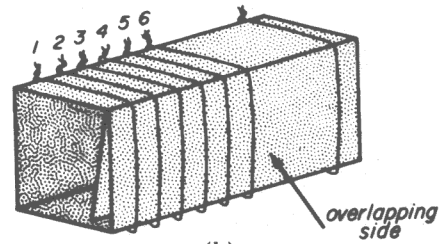
Step 2. As shown in Fig. 32-17*b*, wind a single shorted turn of magnet wire on one end of the cardboard box. Wind 6 shorted turns spaced on the marks numbered 1 to 6 on the template on the other end. Solder all connections.

EXPERIMENT 32-6

To show that a single shorted turn that is not located close to the antenna coil does not cut off the signal.



(a)



(b)

Fig. 32-17

Procedure.

Step 1. Tune in a station on your radio.

Step 2. Place the one-turn end of the cardboard box over the antenna coil. Hold the box so that the antenna coil is centered within the single shorted turn. Observe that the loudness of the sound remains unchanged. This shows that the single wide shorted-turn neither loads nor shields the antenna coil.

EXPERIMENT 32-7

To show that a series of wide shorted turns shields the antenna coil in your radio and reduces the amount of signal picked up.

Procedure.

Step 1. Tune in a station on your radio.

Step 2. Place the six-turn end of the cardboard box over the antenna coil. Hold the box so that the antenna coil is centered within the six shorted turns. When you do so, the volume should decrease somewhat, and the hiss, (if any) should increase—showing that less signal is being picked up.

Discussion. In Experiment 32-6, we demonstrated that a single wide shorted turn does not load the antenna coil. Since the

six shorted turns employed in Experiment 32-6 are each identical to the single turn, you can tell that the reduction of signal pickup is caused by shielding and not by loading of the antenna coil. Of course, practical shields usually are sheet metal boxes and cylinders--not a series of shorted turns--although wire mesh screening is often used for practical shields where ventilation is important.

EXPERIMENT 32-8

To show that there is accidental coupling between the 6AT6 tube and the antenna coil of your receiver and that this coupling forms a feedback path and the feedback causes oscillation. To show that the accidental coupling can be interrupted and the oscillation stopped by shielding the 6AT6 tube.

Procedure.

Step 1. Be sure that the antenna coil slug is positioned flush with the rear of the coil form and that the r-f trimmer adjustment is maximum counterclockwise. (Do not let the screw fall out).

Step 2. Turn on your radio, volume up. Turn the tuning capacitor maximum counterclockwise, then slowly rotate it in the clockwise direction. You should hear motorboat sounds and whistles.

Note: It is possible that the whistles and motorboat sounds will not occur on some receivers. Perhaps they will not occur in yours. If this is so, it means that the coupling does not happen to exist in your particular radio. There is a lesson to be learned here. As you work with mass-produced radio sets, you will find shields that seem to serve no purpose. The reason may be that the shields are necessary in some chassis of the model you are servicing, but not in all. Since the design engineer does not know, in advance, what chassis will require the shields, he has them installed in all the chassis manufactured. Always leave shields in place.

Information. The whistles and motorboat sounds are self-sustained oscillations taking place in the amplifier chain that extends from the r-f amplifier to the converter, to the i-f amplifier, and through the detector to the 6AT6 audio amplifier. Some signal is coupled from the 6AT6 at the end of the chain back to the antenna coil at the start of the chain by capacitive coupling. We will show that the coupling can be interrupted and the oscillation stopped by means of a simple Faraday shield.

Step 3. Position the tuning capacitor to hear whistles and/or motorboating.

Step 4. Select a long-shafted screwdriver and holding it by the handle in a straight up-and-down position, touch the end of the metal blade to chassis so that the metal stands upright on the chassis exactly midway between the 6AT6 and the r-f coil. The shaft should act as a Faraday shield; the noises should stop.

Step 5. Now drop your tubular tube-shield over the 6AT6 tube. Again, the noise should stop.

JOB 32-8

To permanently install the 6AT6 tube shield. (The shield assembly fits together as shown in Fig. 32-18.)

Procedure.

Step 1. Temporarily remove the two mounting screws and hex nuts that hold the 6AT6 socket in place on the chassis.

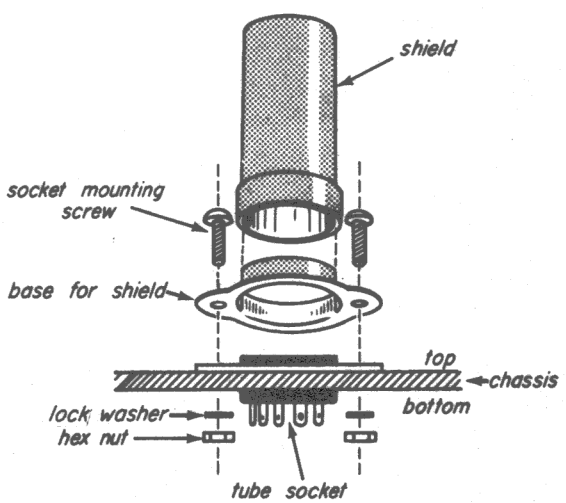


Fig. 32-18

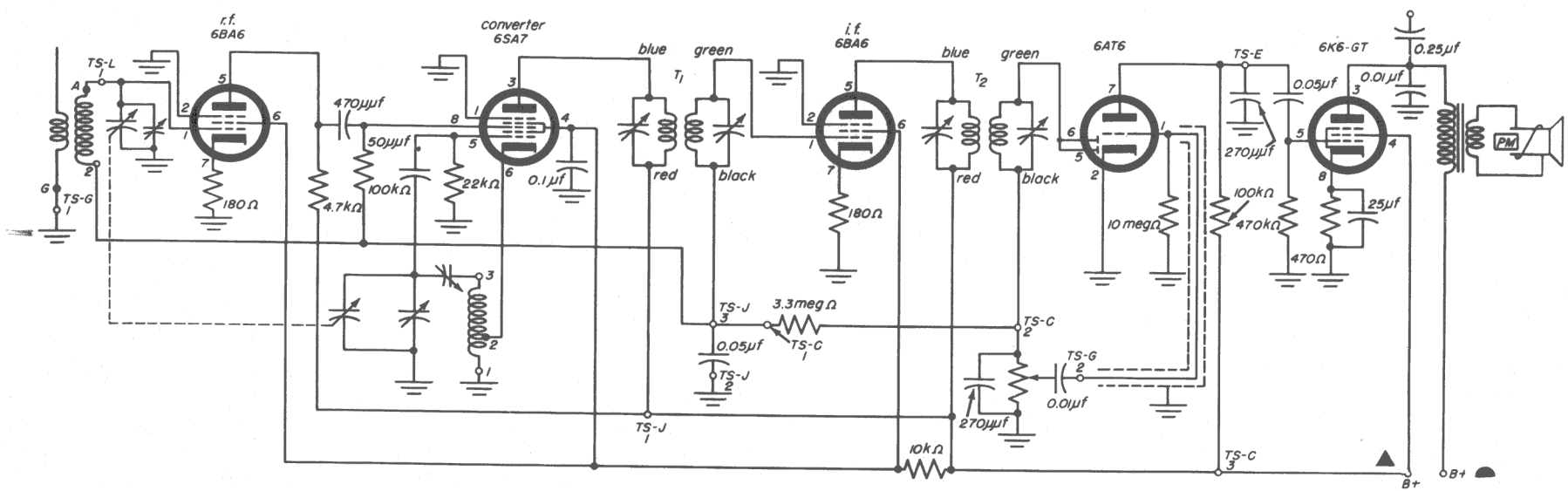
Step 2. Put the tube shield base in place over the 6AT6 socket on the top side of the chassis, so that all the screw holes line up.

Step 3. Screw the shield base and the tube socket to the chassis with the mounting screws you removed in Step 2.

Step 4. Plug in the 6AT6 tube and put the tubular shield over the tube. Push the shield down upon the shield base.

Step 5. Connect the 270-$\mu\mu$f capacitor from pin 7 of the 6BA6 tube socket to the nearest ground lug on the same tube socket. This capacitor is wired to serve as additional precaution against motorboating.

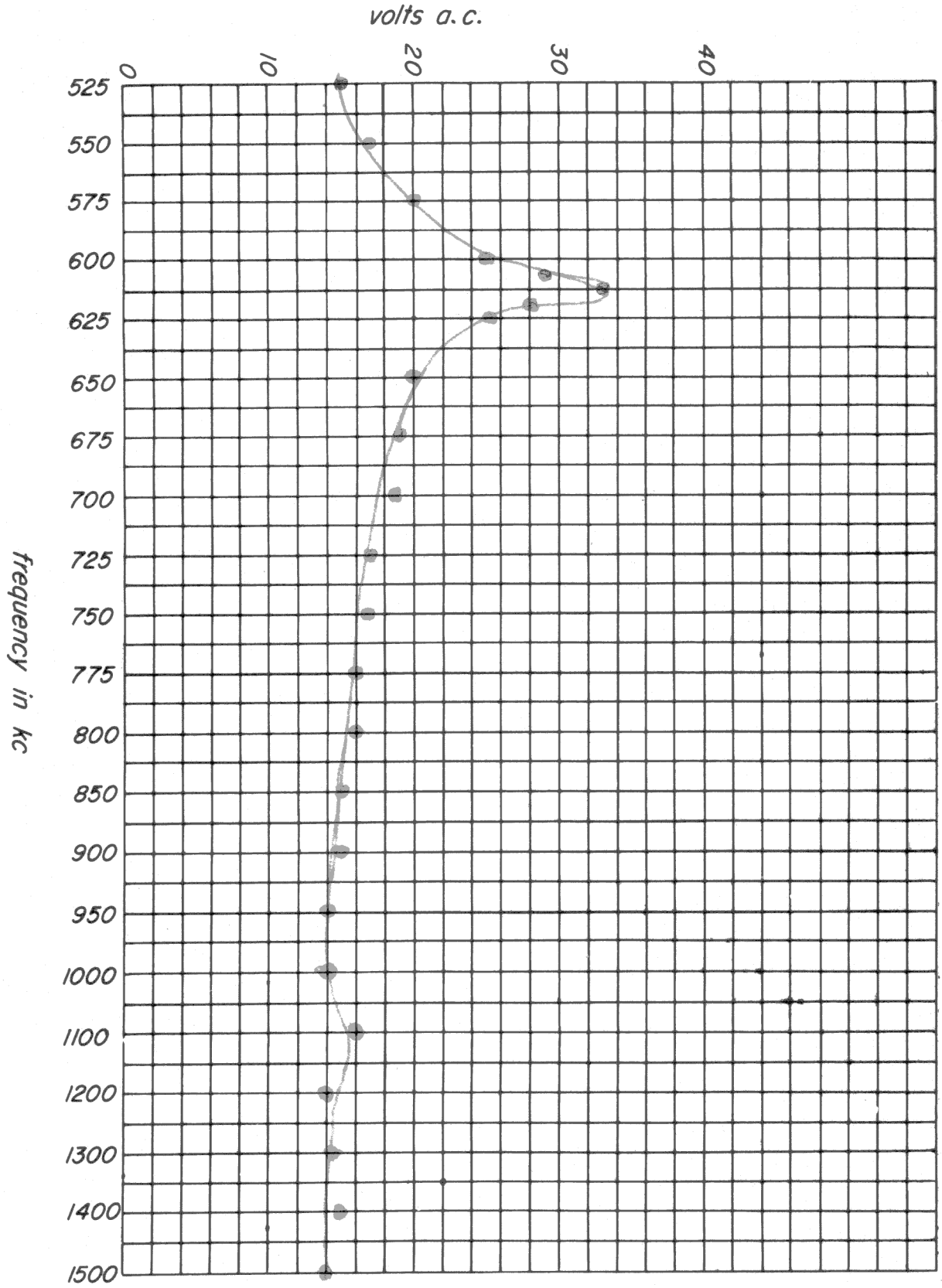
Note: At the conclusion of this lesson, the r-f circuit of your receiver should be wired as shown in Fig. 32-1. A diagram of the completed receiver appears at the end of this lesson.



TS - G - 1-2
L - 1-2
J - 1-2-3
C - 1-2-3
E -

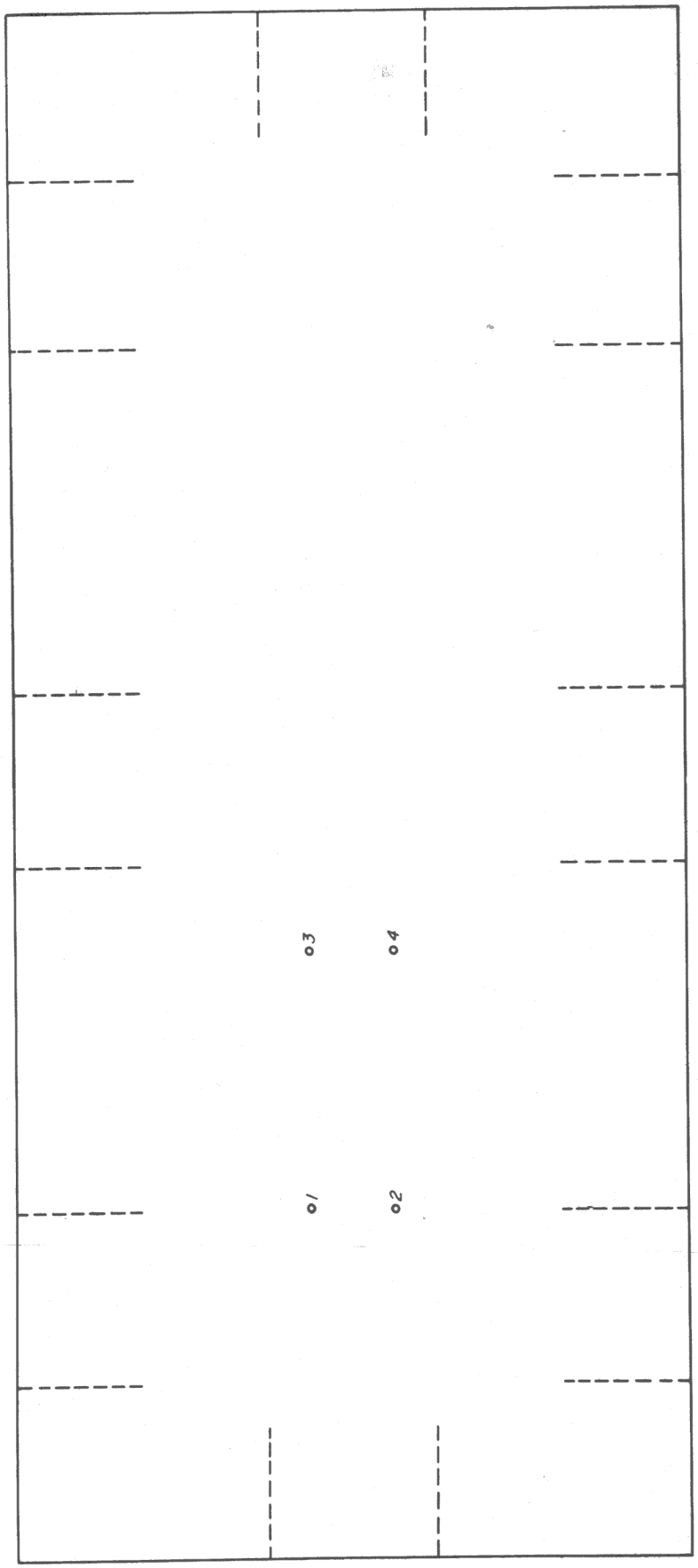
3300000

Condition of Radio Receiver Chassis at End of Experiment Lesson 32

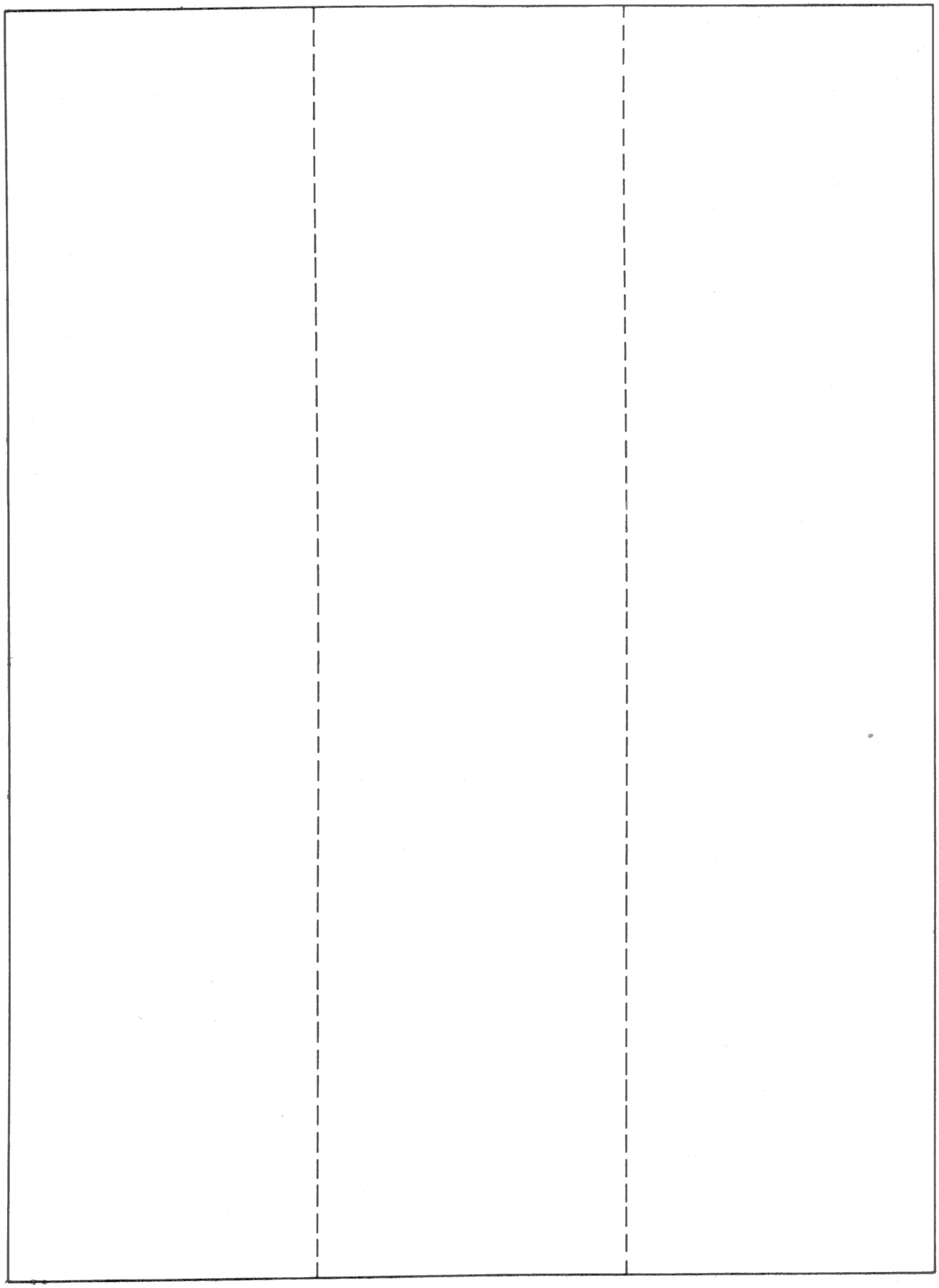


CUT OUT THIS GRAPH PAPER AND USE IT TO PLOT
THE RESPONSE CURVE FOR YOUR RECEIVER.

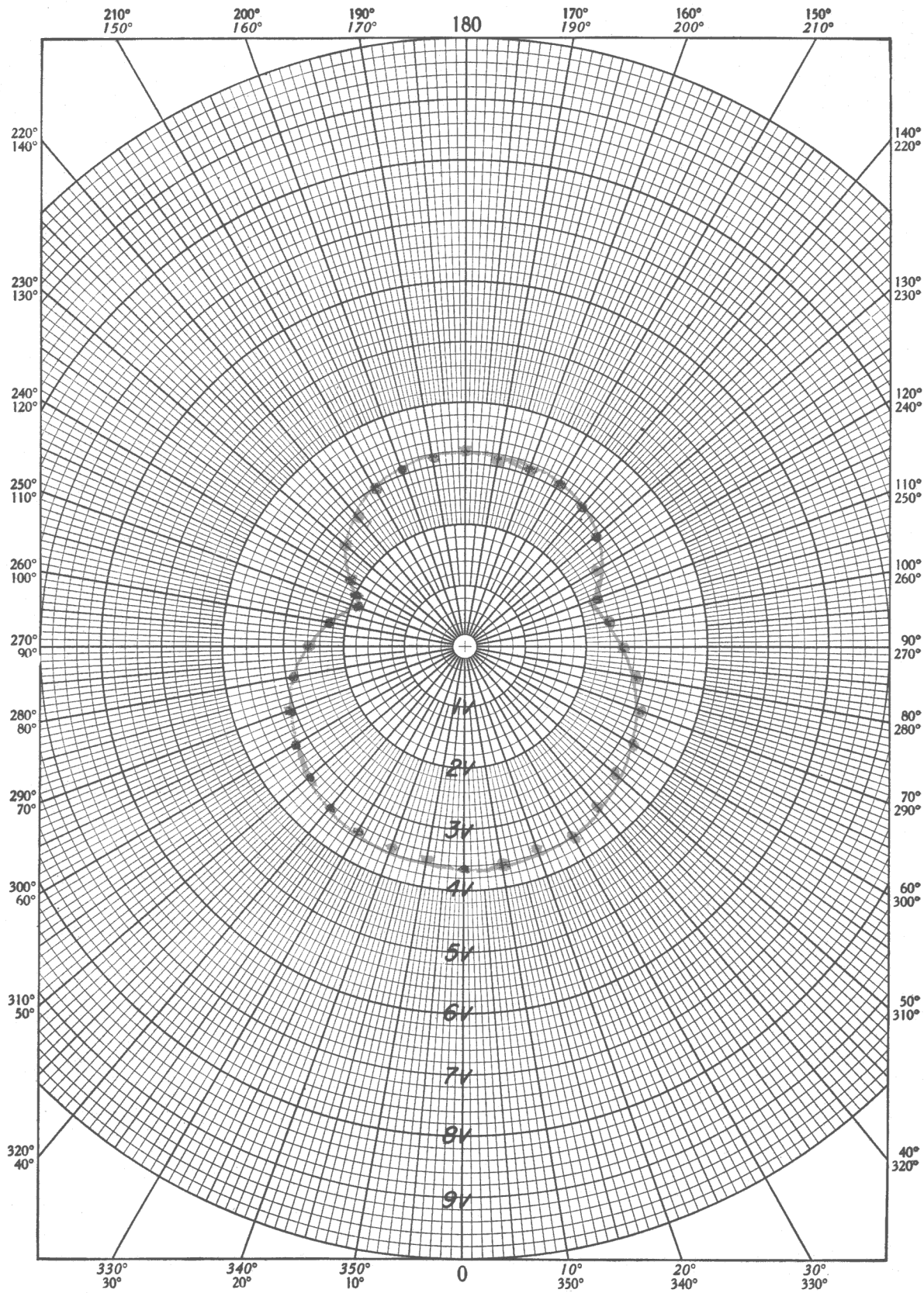
3.0
1.5 | 45.0



CUT OUT THIS TEMPLATE FOR YOUR LOOP ANTENNA
AND PASTE IT ON A PIECE OF CARDBOARD.



CUT OUT THIS TEMPLATE FOR YOUR LOOP ANTENNA
STAND AND PASTE IT ON A PIECE OF CARDBOARD



CUT OUT THIS POLAR GRAPH PAPER AND USE IT TO PLOT THE DIRECTIVITY PATTERN OF YOUR LOOP ANTENNA.

CUT OUT THIS TEMPLATE FOR THE BOX TO
SUPPORT THE SHORTED TURNS OF WIRE